Scheduling—a means for higher productivity

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Abstract :

A complex combinatorial problem associated with production scheduling in a job shop environment remains unsolved today. No real measure of the effectiveness of a schedule as to its closeness to its theoretical optimum value or to the probability of further improvement of the result has been identified. Further, many simplified assumptions regarding scheduling problems have widened the gap between theoretical research and practical need. This paper reports a methodology for solving general problems with an optimal tending technique. It also provides an evaluation procedure to estimate a lower bound and calculate the probability of further improvement by any algorithm.

Introduction

The problem of sequencing has been the subject of extensive research in recent years. In its general context, the sequencing problem is the problem of defining order (rank, priority, and the like) over a set of jobs (tasks, items, commodities) as they proceed from one machine (processor, facility, operation) to another or over the same machine. Thus, the sequencing problem involves the determination of the relative position of job to all other jobs. Moreover, a sequence is obtained when a complete ordering of the jobs is given.

Models

Different sequeneing problems naturally lead to different models, which imply differences in the three basic constituents of model : (i) parameters, (ii) assumptions, and (iii) criteria.

The realm of the job sequencing problem can be decomposed into two general groups: those in which job arrivals are considered to be static and those in which job arrivals are dynamic, that is, varying over time.

In general, with respect to job sequencing problems, systems are divided into those with a single processor and those with multiple processors. Multi-processor systems exhibit almost unlimited varieties of arrangements of facilities and of flow of work through the facilities. In general, the following list of typical simplifying assumptions is made:

1. Assnmptions Concerning jobs

a. All jobs are available at the begining of the planning period.
b. Job splitting is not allowed.
c. No job may be on two processors at the same time
d. No alternate routings of jobs are permitted.

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e. No pre-emption of jobs is permitted.
f. Processing times are known and deterministic.
g. Processing times and setup times are independent of the sequence.
h. There is no priority ranking of jobs.

2. **Assumptions related to the processes**
   a. All machines are available at the beginning of the planning period and are available for any of the jobs.
   b. There is only one process of each type in shop.
   c. Only one job can be processed at any given time by a specific machine.

3. **Others :**
   a. In process inventory is allowed
   b. Due dates are fixed when they exist.

Measure of Effectiveness :

The expression $(n)^m$ where m refers to the machines and n to jobs is often cited for the number of schedules in an nXm problem but provides in general neither a very good estimate nor an upper bound. It is presumably based on the special problem in which each job has one and only one operation on each machine. Nevertheless it should be sufficient to note that for a 6X5 problem, $(6)^5$ is approximately 1.93x1014, which is more than the number of microseconds in six years. From such a large set of schedules, by using the extreme value theorem (4), one can estimate the lower bound and can calculate the probability of improvement from an existing solution, This will provide a distinct advantage in the decision. If Z is the best solution obtained so far and Z min is the estimated lower bound, then the absolute difference 1 Z - Zmin 1 will provide still another dimension for better decision making. The distribution of extreme values has been found to correspond adequately to Weibull distribution (4). Empirical studies of the application of the Weibull have verified its applicability (8). Complete treatment of minimum bound estimation with different problems and algorithms have beeen presented in reference 7(a).

A Generalized Sequeneing Algorithm :

Haque (5) investigated multi-machines multiple facilities system with kuown processing times. Here two of the usual assumptions enumerated earlier were eliminated. These are 2b and 2c-"there is only one machine of each time in the shop" and "only one job can be processed in a machine at any given time." The algorithm can, therefore, effectively handle the situation when there are several machines of each type. The machines may or may not have identical processing times.

The algorithm is a Monte carlo technique. One of the most important aspects of this algorithm is to develop different techniques to increase the quality of the feasible solution of the usual Monte Carlo procedure. Among many other techniques developed (5), figures 1-3 illustrate the improvement over the usual procedure by one such technique which makes a modification to give a better subset of feasible schedules by using the concept of left shifting that permits an operation to "jump over" another operation into an interval of the time if that interval is large enough to accomodate the shifted operation.

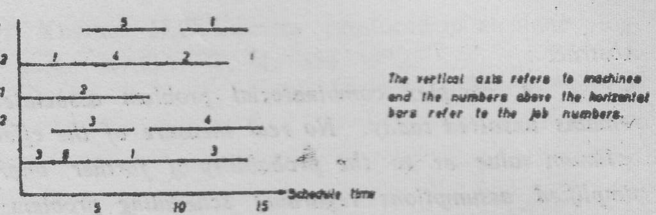

Figure 1. Left-shifting (Schedule time 15)

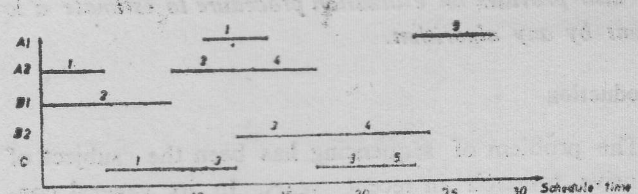

Figure 2 Non-Left-shifting (schedule time 25)

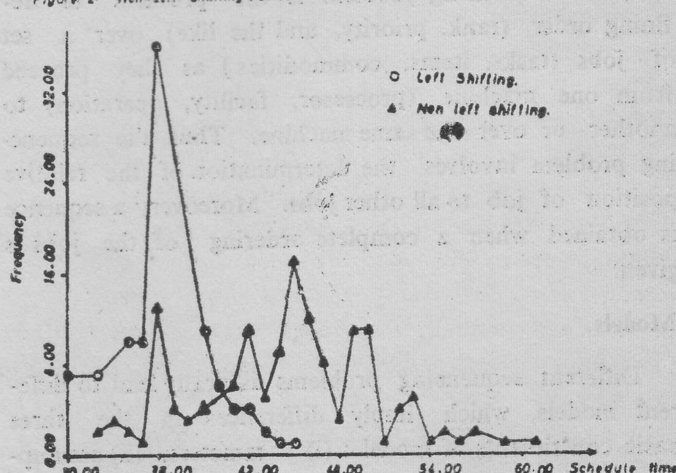

Figure 3 Sample problem (5x4)

The very first step that occurs when shifting from single-machine facilities to multiple-machines facilities is to find which area has the potential need for change. In intermittent industries, usually every job needs some common operations and, therefore, the possible needs for change to multiple-machines facilities should more likely arise from general purpose machines rather than special purpose machines. From past experience management should realize mostly which jobs are arriving and the area of greater accumulation of inprocess inventory,

After management is convinced about the potential need for change in some particular area, the next question which arises is how many additional machines are required. From past records of job arrival, management should be able to roughly calculate the expected number of different jobs in the shop at a particular time. On the basis of this set of jobs, computer simulation may be carried on to determine the "optimum" number of machines needed at a particular facility. A cost function must be defined and by varying the number of machines, a trade-off point should be determined. Savings due to reduced schedule time and inprocess inventory should justify the increased expenses due to cost, idle time, maintenance, etc., of the additional machine units.

In the literature, halting techniques that are used to stop the sampling procedure such as (3), (9) could not be accepted as operational tools because they either heavily relied upon prior distribution of sequence payoffs or subjective coefficients, though they are conceptually valid. Haque (5) constructed stopping rules that are distribution free and can easily incorporated into any algorithm. Details of the stopping rules and the above algorithm will be available in references (6) and (7).

Assumption 2b considers that at most one job can be processed on a specific machine at any given time. This eliminates operations in facilities such as ironworker, heating ovens, chemical treatment tanks, multidock terminal at a ware house or manufacturing facility, all of which are commonplace processes that handle multiple jobs simultansously. The above assumption has been relaxed in the algorithm and thereby the above situations can be easily brought within its scope.

The above algorithm can be modified for use to the transportation problem which includes the consideration of the routing of trucks when carrying a product and when the trailer is empty (5). The facilities were split into 3 groups : origins, destinations and the trucking terminals or maintenance shops. Trucks referred to the respective jobs to be processed.

Summary and Conclusion :

Current scheduling techniques found in the literature because of the most simplified assumptions involved in them could not find wide applicability. However models for multiple machine systems can be handled with optimal tending procedures which when coupled with good stopping techniques are relatively efficient wlth respect to the quality of the solution and the resources needed for obtaining the solution. Application of extreme value statistics by which a minimum bound for scheduling time can be estimated provides still another distinct advantage to this model.

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